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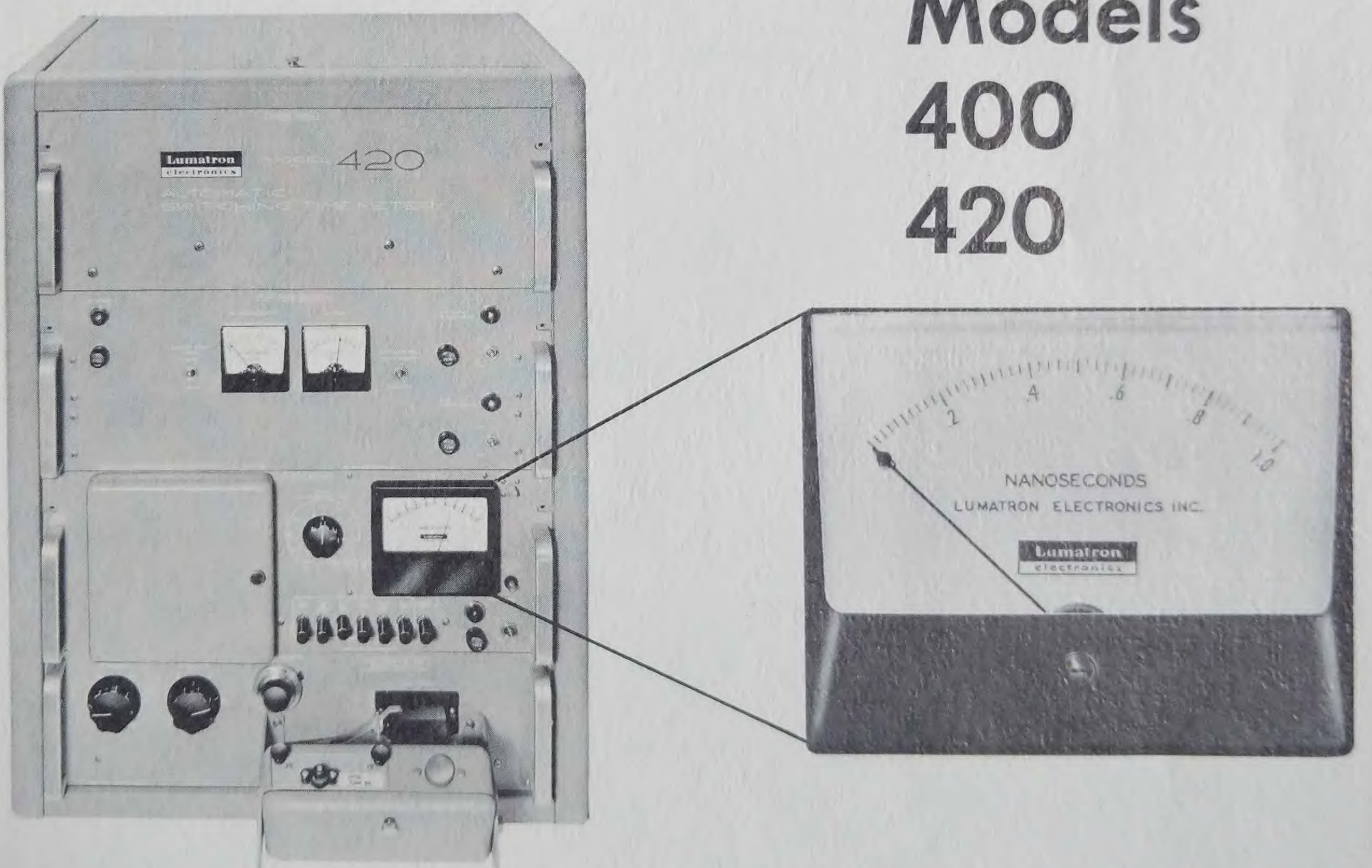
AUTOMATIC SWITCHING TIME TEST SETS

for the automatic measurement of millimicrosecond switching times in semiconductor devices and circuits.

Models 400 420



MODEL 400 – from 0.5ns* to 1μsec with better than 4% accuracy

MODEL 420 – from 1.0ns* to 2μsec with better than 5% accuracy

*(Note: $1ns = 10^{-9}$ sec.)

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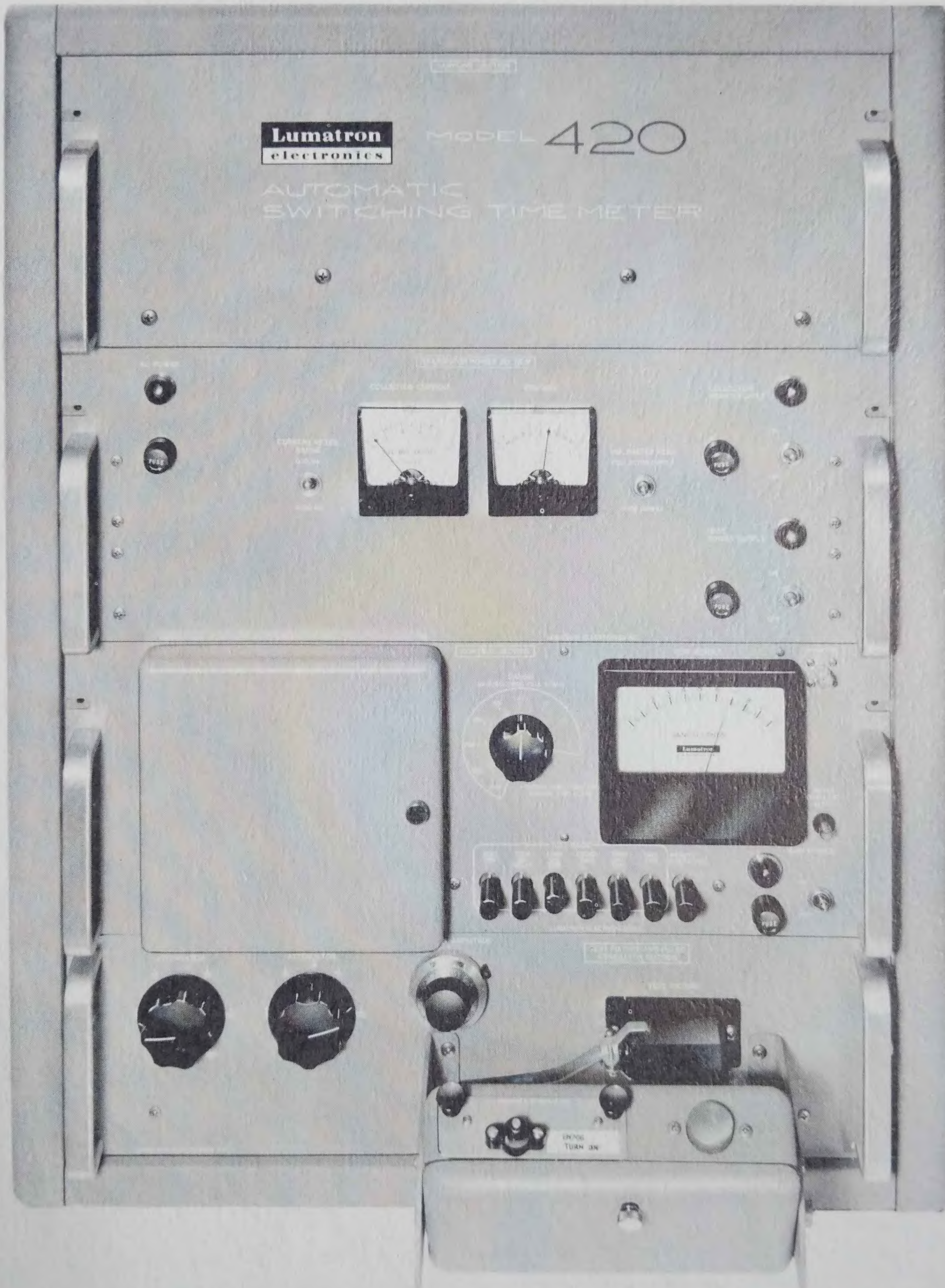


MODEL 420, AUTOMATIC SWITCHING TIME TEST SET

AUTOMATIC SWITCHING TIME TEST SETS

for the automatic measurement of millimicrosecond switching times in semiconductor devices and circuits.

Direct Meter Reading and Automated Read-out

For Production, Quality Control, Incoming Inspection and Laboratory

CAPABILITIES:

		MODEL 400	MODEL 420
Time Measurements:	Ranges:	0.5ns – 1μsec	1.0ns – 2μsec
	Accuracy:		
	Voltage Output	±4% of reading ±0.2ns	±5% of reading ±0.4ns
	Meter Reading	As above, plus meter accuracy of ±2% (max) F.S.	As above, plus meter accuracy of ±2% (max) F.S.

Types of Test: Measures switching times such as risetime, turn-on delay, turn-on time, fall time, storage time and turn-off time as the time difference between two preselected percentage levels.

Accuracy of Test: The accuracy of the time calibration is based upon the known, physical constant of a calibrated delay line. Percentage levels are derived potentiometrically from precision resistors – independent of pulse amplitude and shape. The instrument can be readily setup to ignore waveform irregularities, such as overshoot and ringing. (Thus, the measurement is NOT dependent upon secondary oscilloscope measurements.)

Device Test Cards: The Model 400 Series instruments employ a plug-in test card which permits maximum flexibility in specifying test circuits for the devices to be evaluated. This test card provides a special high frequency test socket and the test circuit. It also automatically sets up the test conditions, bias currents, collector voltages, test pulse polarity and amplitude. Each test card is carefully designed to reduce "ringing", "feed through" and distortion which can be troublesome when making measurements of extremely fast devices.

These test cards may be permanently wired, retained and re-used at any time. The test cards also permit close correlation. A single card, or multiples of identical cards, may be used in several test positions. In addition, they can be used by customer and vendor for test correlation, in conjunction with either the Model 400 Series test system or a fast oscilloscope†.

Remote Programming and Testing: The test fixture may be located remotely from the instrument – for automated production, and for environmental testing.

Operation:
(a) Manual – tests are selected by manual switches and the test results are read on a mirror scale panel meter.
(b) Automatic (optional) – tests may be sequenced automatically. Test result is available as an analog voltage for go – no go testing, or for conversion to printed or punched information

Test Pulse Generator: 0.3 ns risetime, 120 cps nominal, calibrated output to ±100V, 200 ns pulse width.

Built-In Calibration: No external test equipment required.

Construction: Modular construction employed. Removable, plug-in circuits mounted in slide-out drawers.

† *Lumatron Model 112 Millimicrosecond Sampling Oscilloscope.*

DESCRIPTION:

The Model 400 Series AUTOMATIC SWITCHING TIME TEST SETS are designed for the accurate, rapid evaluation of transistors, tunnel diodes, computer elements and circuits at millimicrosecond switching speeds. Measurements to a fraction of a nanosecond* can be made accurately and fast, permitting operation by inexperienced personnel, and the installation of test sets in fully automatic production lines. The test sets measure all time parameters important to fast devices, including risetime, fall time, turn-on delay, storage time, turn-on time and turn-off time.

Faster switching devices and circuits are constantly being developed. Other automatic testing methods in use operate at the upper limits of their technique and will rapidly become inadequate as these faster devices become available. An important advantage of the Model 400 is, therefore, the extreme speed of its fast ranges. While many present applications may not yet require these extra capabilities, the full capabilities of the Model 400 will keep it from becoming obsolete as faster tests do become necessary.

Four new techniques are combined to make possible measurements of nanosecond * switching times from 0.5ns to 1 μsec with a maximum accuracy of ±4%. (1.0ns to 2 μsec ±5% in the Model 420). They are:

A. PROGRAMMED TESTING
Testing of fast switching devices is usually done in a particular test circuit, which is specified for each device type. LUMATRON provides inexpensive plug-in test cards which can be wired either by the factory or the customer for any test circuit. The careful construction of each test circuit permits millimicrosecond operation of the device under test. The card also provides simple programming circuits which set up the test conditions for the device being tested, such as bias voltages and polarity of the pulse. This technique is also adaptable to the testing of circuits and circuit cards.

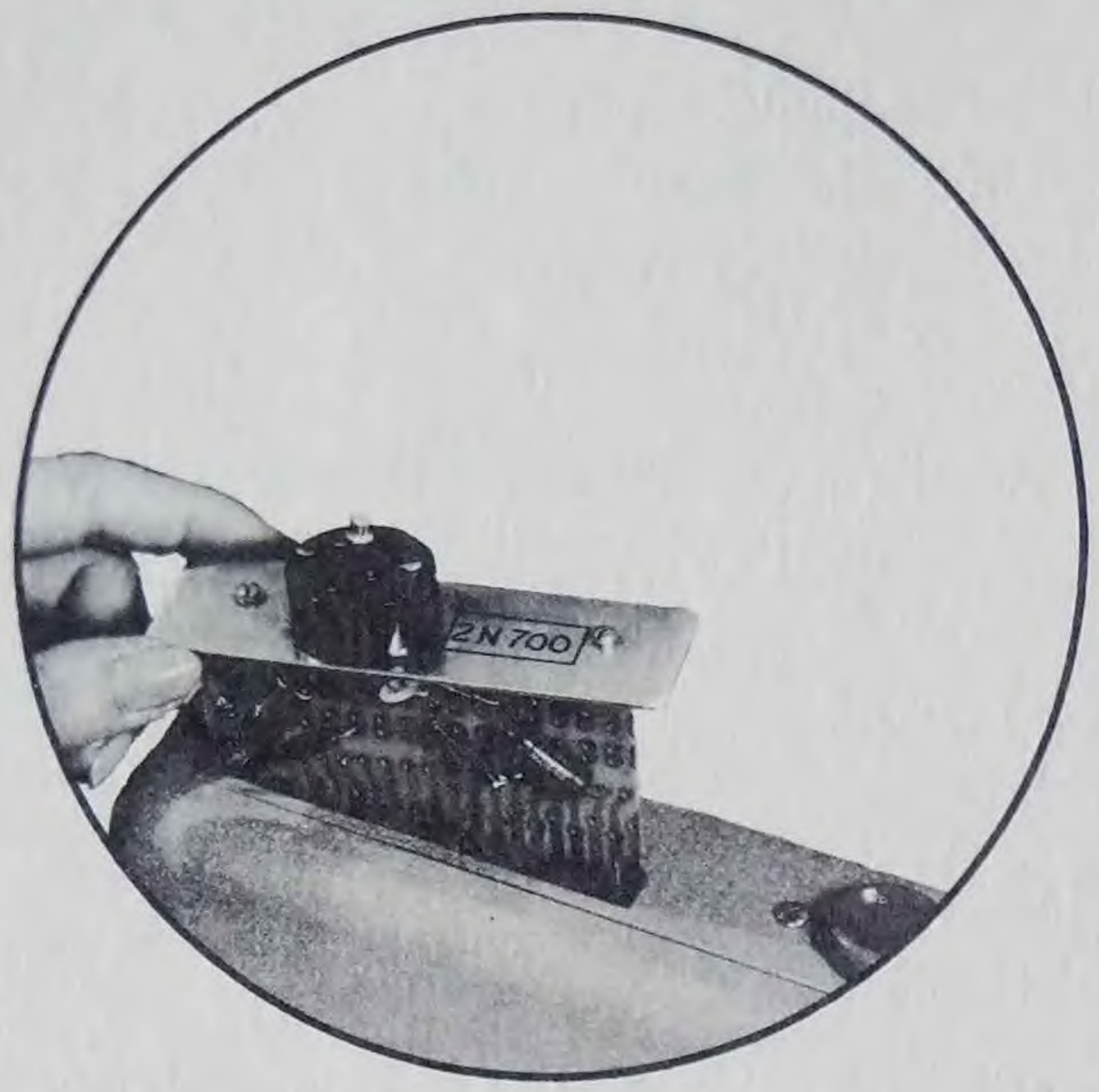
B. THE SAMPLING TECHNIQUE
This method, first pioneered by LUMATRON in sampling oscilloscopes† permits precise measurements on a "slowed down" amplified waveform – free from the problems normally encountered in millimicrosecond testing.

C. THE NORMALIZING TECHNIQUE
This unique system permits the instrument to read time between percent (not voltage) levels. Reference and peak voltage levels, measured before the start of the pulse and at the top of the pulse, are stored. The difference between these two voltage levels becomes 100%, from which 10% and 90% levels are accurately calculated. This measurement is a true measurement between percentage levels, (rather than voltage levels), and is independent of the amplitude of the pulse being measured, or gain changes of the device, test system, or power supply regulation.

D. COMPUTING
The use of analog and digital computation methods provides accurate conversion of switching time (between preselected test limits) to an easily measured analog voltage. It substitutes, in effect, precise electronic comparators for subjective, visual methods.

**1 nanosecond = 1 millimicrosecond =* 10^{-9} *sec.*

TRANSISTOR TEST CARD



The Model 2120 Transistor Test Card is a specially designed and carefully laid-out circuit card which provides the socket and test circuit for transistors. The test card, when inserted into the test jig, also programs the Test Set for the desired test voltages and polarities.

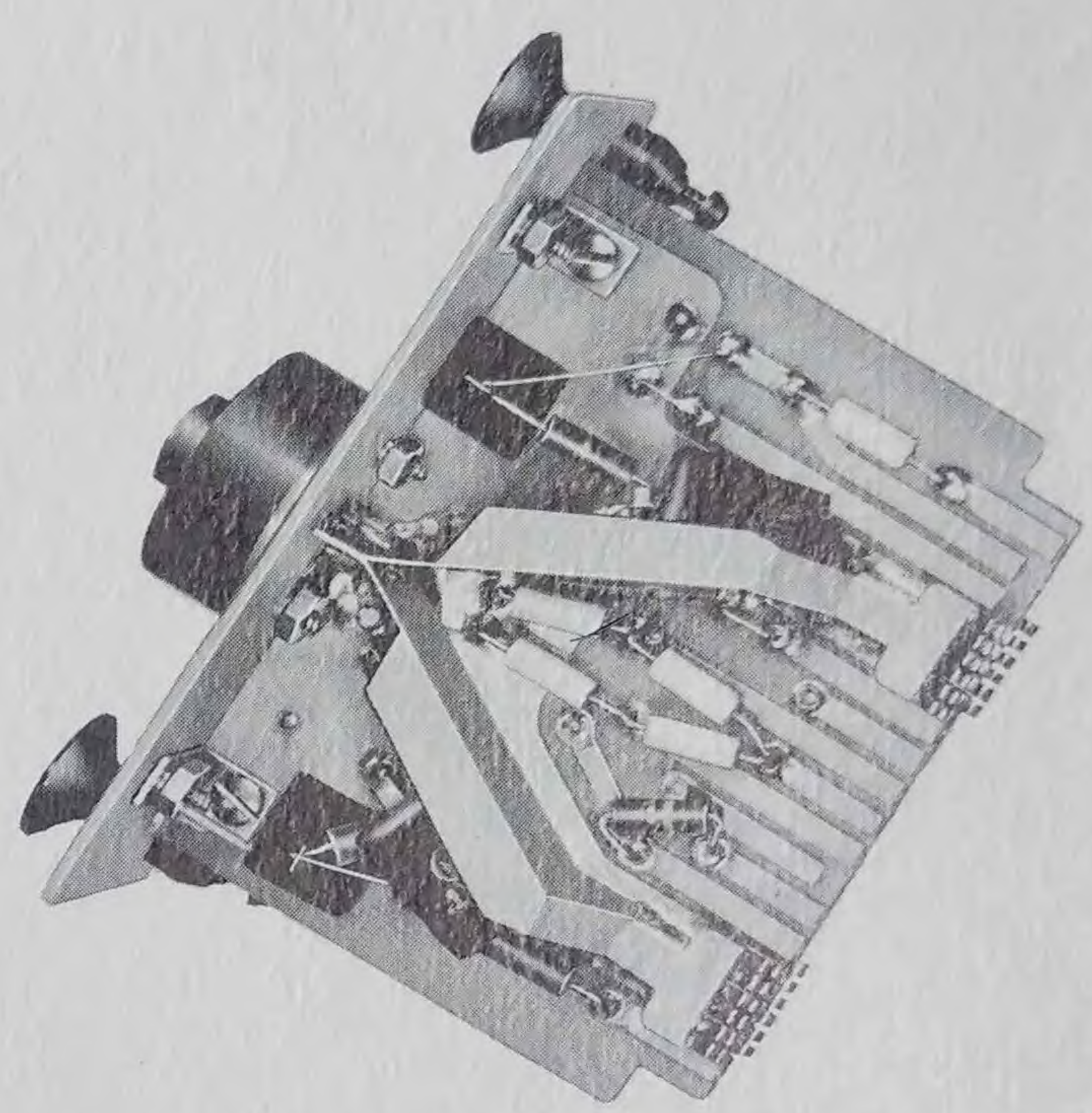
HIGH FREQUENCY SOCKET. The socket, which exhibits low feed-thru capacitance, employs heat-treated Berylium Copper contact pins inserted into a teflon bushing. A properly designed metal base separates and holds the bushings. The base, in turn, is enclosed by a plastic socket which provides an insertion guide for the transistor leads. Guides for either long or short lead transistors are available.

PRINTED CIRCUIT CARD. The card, itself, is an epoxy impregnated fiberglass printed circuit board provided with special ground planes and shields, to reduce ringing, feed-through and distortion. The card, in conjunction with the low capacity socket, offers approximately 70 db of isolation between input and output in a grounded emitter configuration. (Other configurations optional).

TEST CIRCUITS. The transistor test card can be wired to conform to virtually any specified test circuit. A standard layout and placement of components is utilized, offering both optimum performance and flexibility, while retaining a fixed configuration.

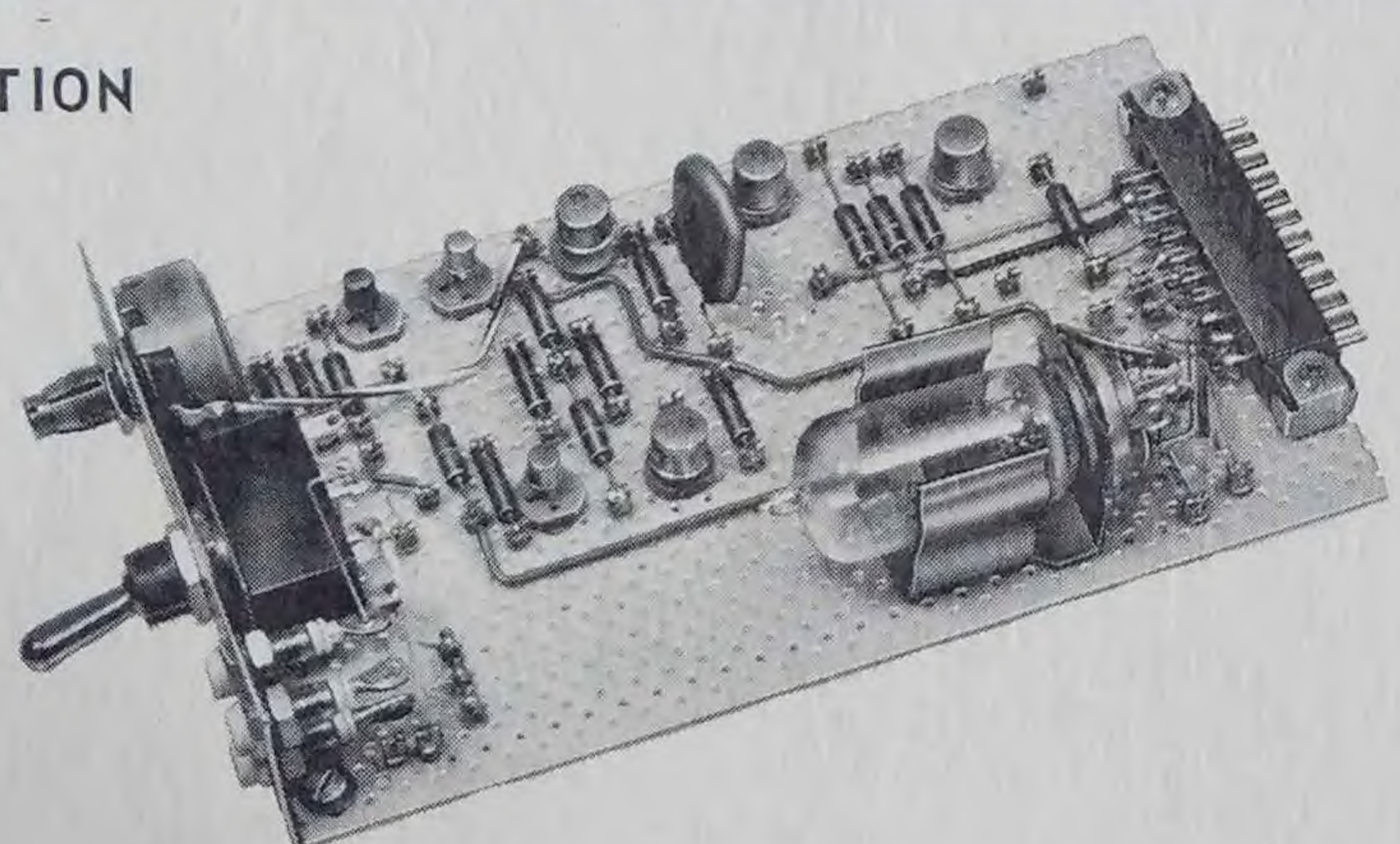
PROGRAMMING. The fully wired card also contains programming components which automatically set the proper test conditions, such as bias amplitude and polarity and input test pulse amplitude and polarity. Programming can also be arranged to automatically change test conditions when turn-on and turn-off measurements are made with the same card.

ADVANTAGES. This unique test card eliminates considerable set-up time, provides excellent millimicrosecond circuits, and permits close correlation between test systems. It also permits close correlation and exchange of data between vendors and users.



MODEL 2120 TRANSISTOR TEST CARD.

CONSTRUCTION FEATURES AND SERVICING



The Model 400 series test sets employ a modular circuit construction to permit easy troubleshooting and accessibility of all components.

Only high quality, derated components are used throughout. All circuits are carefully tested for reliability and long life. Wherever possible, components are mounted on modular circuit cards which can be easily removed for replacement or bench testing.

Each circuit card has the necessary alignment controls and test points brought out to the top of the card for easy troubleshooting and calibration. The removable circuit cards are mounted in slide-out drawers for excellent accessibility. An extension socket permits servicing a card while the instrument is in operation.

A monitor jack is provided on the front of the test set. The output at this jack is the sampled, output waveform of the device under test. This output can be viewed on a conventional oscilloscope and studied with ease.

MODEL 420 CONTROL DRAWER OPENED TO SHOW ACCESSIBILITY OF COMPONENTS AND MODULAR CONSTRUCTION.

APPLICATIONS:

1. PRODUCTION TESTING

Accuracy, speed, reliability, and ease of operation make the Model 400 Series Automatic Switching Time Test Sets particularly adapted for the production testing of fast switching devices and circuits. Control over test conditions is removed from the operator by a cover over part of the front panel. Test cards are modular and relatively inexpensive, so that one card may be wired for each device type under test. Replacing the test card eliminates set-up time when changing from one device to another. After completion of test on one type of device the test card can be removed and stored, and another test card plugged into the front of the instrument.

The voltage output of the instruments can be used to actuate go-no go comparators (optional), or can be read on digital voltmeters, or converted into printed or punched information for records and statistical analysis.

The Model 400 Series Switching Time Test Sets can reduce time and costs in production testing by eliminating the need for difficult, subjective "scope" measurements. Moreover, they can quickly pay for themselves by eliminating the need for wide "guard bands" in test tolerances – producing higher yields, a more uniform product, and more accurate test data.

2. INCOMING INSPECTION AND QUALITY CONTROL

Convenience in changing from one type of device to another makes the Model 400 Series particularly adaptable to incoming inspection and quality control operations. Test circuits can be interchanged and correlated between manufacturer and vendor. Using the same test card, similar devices from different manufacturers and different batches can be tested and evaluated under identical conditions. Accessory digital equipment may be used to obtain printed or punched data, which can be statistically evaluated and stored in permanent form. Recorder plots of actual typical signals from the device under test can be made and retained for correlation of data.

3. IN THE LABORATORY

The ease with which test conditions may be changed, reproduced and verified, make the Model 400 Series extremely adaptable for laboratory work in which small quantities of devices or circuits can be tested rapidly under varying conditions. The instruments, therefore, are capable of saving the time of scientific and engineering personnel by reducing switching time tests to simple, accurate, quantitative measurements. Permanent records can be retained for evaluation at a later date.

MODEL 420, SET UP FOR TESTING OF FAST SWITCHING TRANSISTORS, USING DIGITAL VOLTMETER AND FLEXOWRITER FOR TABULATION OF RESULTS

CIRCUIT DESCRIPTION:

The Model 400 series instruments derive their superior performance from a combination of advanced millimicrosecond and computer techniques.

1. "SAMPLING" of the nanosecond* waveform is used to produce a "slow" replica, which can be analyzed with ease and accuracy. Sampling permits analysis of a nanosecond waveform in the same way that a stroboscope permits the viewing of a rapidly moving mechanical device. The actual measurement is made automatically from the resultant samples of the signal.

   The circuits are shown in simplified form in the block diagram, Figure 5. A built-in, ultra-fast mercury switch generator (less than 0.3 ns risetime) initiates operation of the circuits through the trigger amplifier, starting the fast sweep generator. At a time determined by the fast sweep generator and an advancing comparison voltage, a "strobe" generator fires and injects an extremely narrow sampling pulse into the sampling head.

   The output from the pulse generator is also used to pulse the device being tested. The resulting signal is delayed for about 100 ns by a wideband coaxial delay line and arrives at the sampling head late enough to allow sampling of the signal prior to its leading edge. The time of sampling of successive pulses is advanced during repetitive periods by a slow ramp, until the entire signal has been scanned. This operation is repeated for each test.

   The sampling pulse and the signal are mixed in the sampling head. The output of the sampling head is a very fast pulse, the amplitude of which is proportional to the instantaneous amplitude of the signal being analyzed. This output pulse is pre-stretched, and then amplified in a linear amplifier of moderate bandwidth. The amplifier output, in turn, is fed to a pulse stretcher.

   The output of the stretcher appears as a train of pulses, whose envelope is a time expansion of the input signal. This "slowed down" signal is analyzed, and time differences are presented as voltage levels to the output connector or the test result meter.

   The principal design differences between the Model 400 and 420 series instruments are found in the construction of the sampling circuits. The Model 400 series employ tubes in the nanosecond circuit which, while larger and more expensive, offer the fastest risetimes, greater time stability and highest sensitivity. The Model 420 series use, predominantly, solid state circuits which offer slightly less performance, at considerably reduced size and cost. This performance is, however, still far superior to that of any other currently available instrument, except the Model 400.

1 nanosecond = 1 millimicrosecond = 10^{-9} sec.

2. NORMALIZING of the pulse amplitudes makes the time measurement between percentage levels of pulse amplitude independent of the pulse voltage levels.

   An operational sequence is shown in Figure 6. The measurements are normalized by first sampling and storing the peak level of the output signal and then by sampling and storing the reference, or zero, amplitude of the output signal. The subtraction of these two voltage levels in the pulse height normalizer, determines the 100% value. The 10% and 90% values, or any other desired percentage levels, can now be derived from the 100% value, and time readings will, essentially, be independent of variations in signal pulse amplitude.

3. CONTROL AND COMPUTER TECHNIQUES are used to store data and convert TIME between percentage levels into an output VOLTAGE. Typical sequences are shown on Page 7.

   The sequence depends on the type of measurement to be made. Measuring Risetime, for example, requires a single scan of the leading edge of the signal pulse. The same slow ramp voltage, which produces this scan, is sensed and stored at the 10% level, and again at the 90% level of the signal. The difference between these two voltages appears at the output jack, representing the elasped time (in nanoseconds) between 10% and 90% of the signal pulse.

   To measure Turn-On Delay, the 10% points of the output signal and of the test pulse must be found. A coaxial switch transfers the input to the sampling circuits from the device under test to the mercury switch pulser so that its leading edge can be measured in the same way as the leading edge of the output signal. The voltages of the slow ramp at the two 10% points are stored and subtracted, resulting in a voltage corresponding to their time differences -- in nanoseconds.

4. PROGRAMMING:

   The use of programmable power supplies permits the setting of base and collector voltages and polarity by inserting appropriate resistors on the test cards. The card also switches test pulse amplitude and polarity. Thus, the desired test conditions for PNP or NPN transistors are automatically and rapidly set up.

   Remote programming of test conditions and test sequences is available as optional equipment.

5. FUTURE CAPABILITIES:

   It is characteristic of the design of the Model 400 and 420 that their abilities to measure even faster switching times than those specified depend on the availability of certain components. As these components become available, it will be possible to further increase the capabilities of the Model 400 and Model 420. Thus, as industry develops requirements for testing faster components, our instruments will be able to increase their capabilities of measuring them.

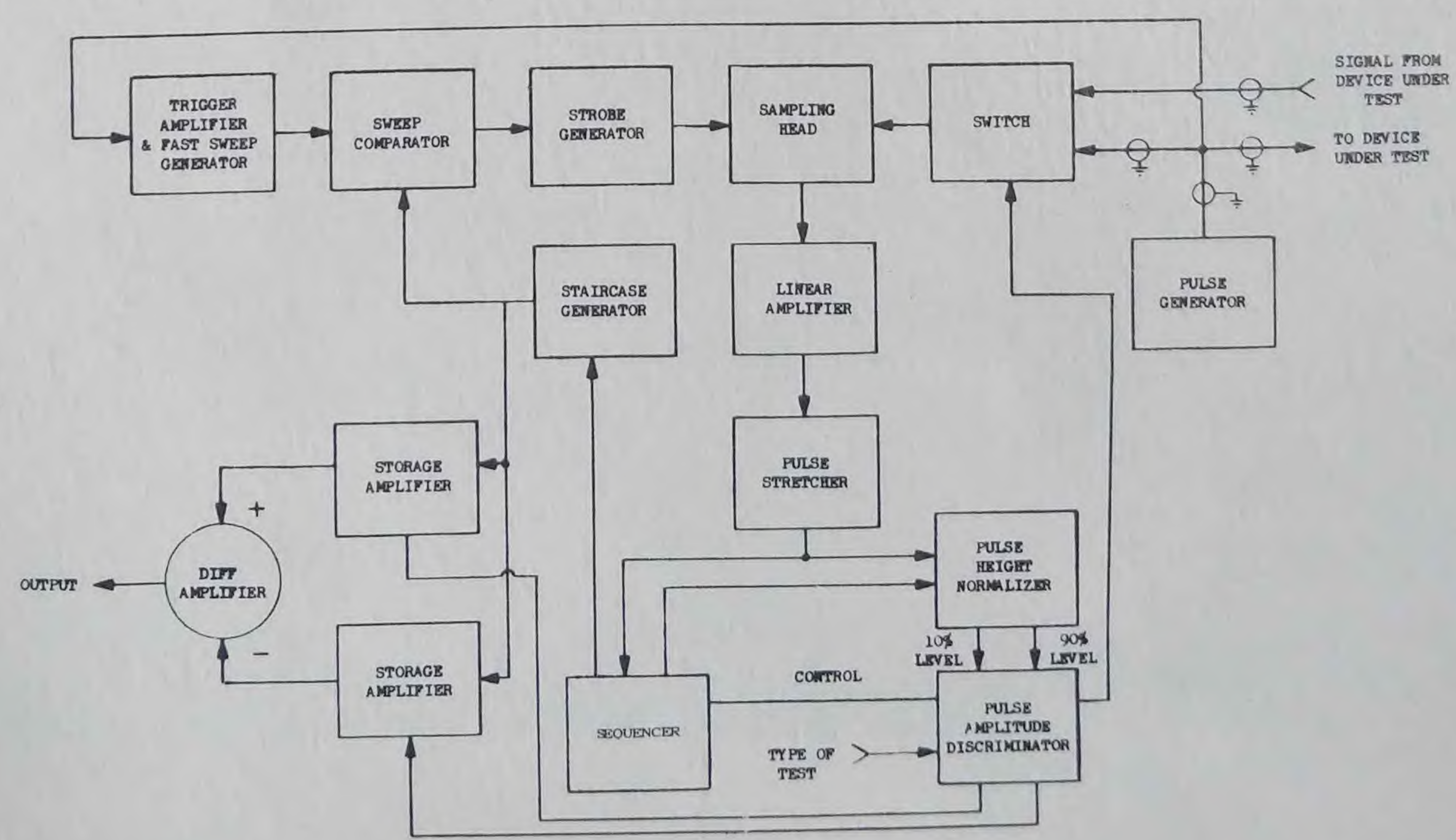


FIGURE 5 – BLOCK DIAGRAM

TYPICAL OPERATIONAL SEQUENCES

The sequences described below show how the Model 400 Series Test Sets measure the sampled waveform, EXAMPLE: To measure Risetime, the voltage at the top of the signal pulse is first measured and stored (Peak Time). Next-the voltage at the base of the pulse is measured (Reference Time), and subtracted from the Peak Voltage. The system now computes and stores the 10% and 90% levels. The sampled waveform is then compared to these stored levels to determine the voltage difference between them and display it as TIME at the output.

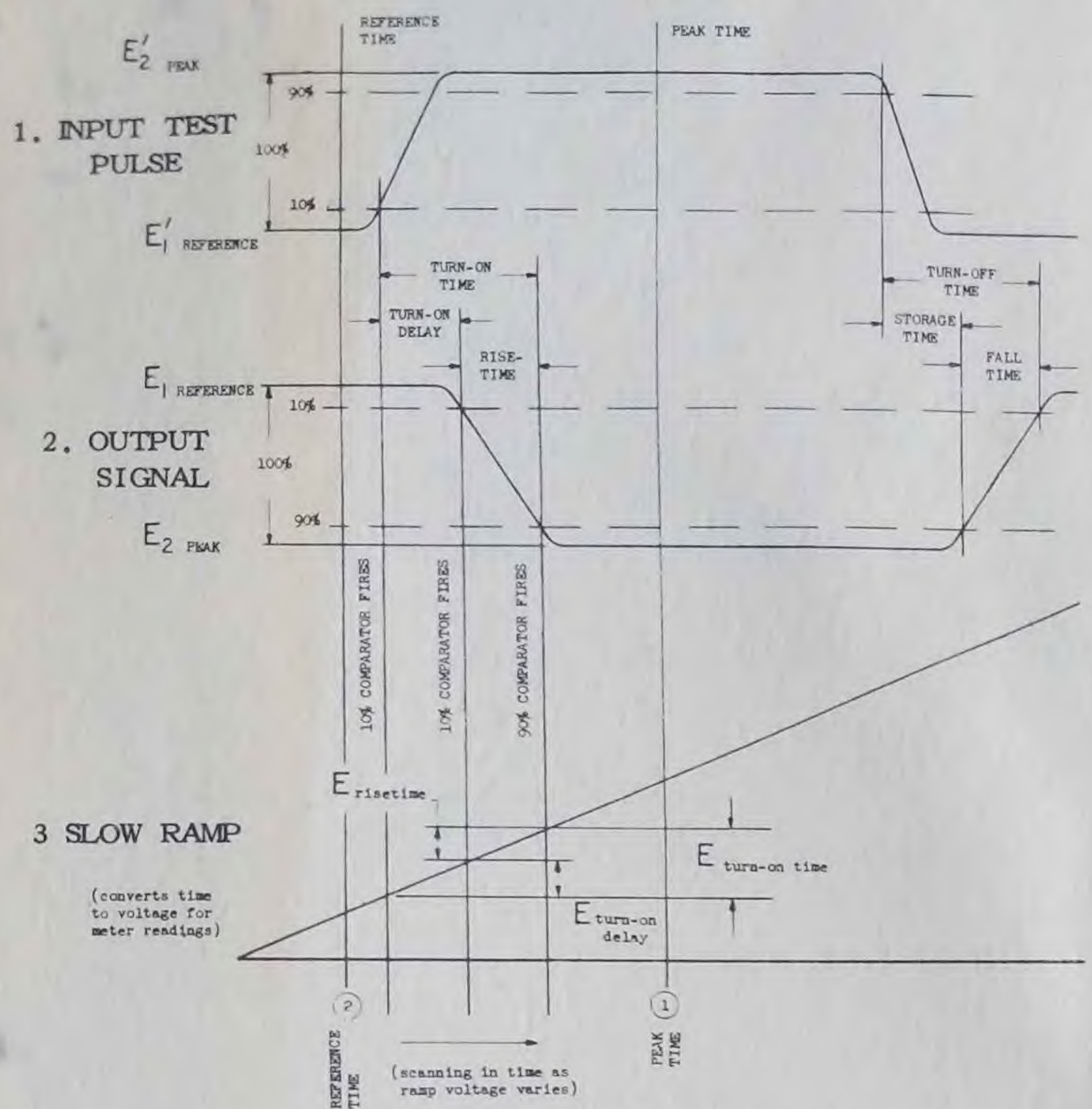


FIGURE 6 – TIMING DIAGRAM

TIME — OPERATION

A. RISETIME

1. Peak Time .... Stores E_2 (Maximum output signal at top of pulse).
2. Reference Time......................... Stores E_1 (Reference level at baseline). Calculates $(E_2—E_1) = E_{100\%}$ and stores.
3. --- ....Calculates and stores 10% & 90% of $E_{100\%}$. Sets comparators at these 10% and 90% levels.
4. Starts scanning at reference time.................Stores ramp voltage when 10% comparator fires ($V_{10\%}$)
5. Continues scanning in time........................ Stores ramp voltage when 90% comparator fires ($V_{90\%}$)
6. --- *.....Calculates difference $(V_{90\%}-V_{10\%})$ voltage (from steps 4 and 5) representing time. Displays on meter as RISETIME.

B. TURN-ON DELAY

1. thru 3. Same as for risetime

4. --- ....Stores ramp voltage when 10% comparator fires($V_{10\%}$)
5. --- ......Input coax relay substitutes Input Test Pulse for Output Signal
6. Peak Time...............Stores E'_2 (Maximum level at top of Input Test Pulse).
7. Reference Time....Stores E'_1 (Reference level of Input Test Pulse baseline).
8. --- ....Calculates $(E'_2—E'_1) = E'_{100\%}$ and stores. Calculates and stores (10%) of $E'_{100\%}$ and (90%) of $E'_{100\%}$: Sets comparators at these levels. (10% and 90%).
9. Starts scanning at reference time ...Stores ramp voltage when 10% comparator fires $V'_{10\%}$.
10. --- ....Calculates difference $(V_{10\%}—V'_{10\%})$ in ramp voltage (from steps 4 and 9) representing time. Displays on meter as TURN-ON DELAY.

SUMMARY OF ADVANTAGES

The Model 400 series instruments are designed to supersede less accurate methods which depend directly, or indirectly on an oscilloscope measurement. The Model 400 series instruments use a combination of four basic techniques: Programming, Sampling, Normalizing and Computing. This approach assures reliable readings of high speed switching time characteristics with a minimum of set up time and maximum of flexibility.

1. NANOSECOND READINGS. Switching time measured to 0.5 ns in the Model 400. (1.0 ns in the Model 420.)

2. EXCELLENT ACCURACY. Better than ±4%±0.2ns in the Model 400 and ±5%±0.4ns in the Model 420.

3. RELIABLE TEST RESULTS -- derived from an analysis of the actual signal and not from a secondary effect which may be only indirectly related to the waveform. Test results are, generally, independent of waveform irregularities.

4. POSITIVE VERIFICATION -- amplitude vs. time can be observed on the test meter by manually scanning through time. Permanent records of the pulse shape can be produced on a conventional X-Y recorder.

5. FLEXIBILITY. The instrument may be programmed to perform time measurements between percentage levels on a fast switching waveform. No special preamplifiers are required to perform different tests. The actual test conditions, such as the percentage levels at which measurements are to be made, are easily set up without requiring additional test equipment. These controls are located behind a front panel cover in order to keep them, when desired, from the control of the operator.

6. REPRODUCIBLE TEST RESULTS. Device test circuits are mounted on small, standard plug-in cards, which include a specially designed, millimicrosecond test socket. The card positions all test circuit components and automatically programs the test conditions. These relatively inexpensive cards may be retained for each transistor or device type, and reused at any time. This considerably reduces the set-up time when many different types of devices are to be tested.

7. REMOTE TESTING. The test fixture may be located remotely from the instrument – for automated production, and for environmental testing.

8. CONVENIENT SELECTION OF TEST. Convenient controls select the type of test to be performed, such as risetime, storage, delay, etc. Optional automatic programmers permit sequential performance of a virtually unlimited number of tests without operator command.

9. BUILT-IN CALIBRATION. No additional equipment is required to check the performance of the instrument. A built-in, calibrated delay line is provided so that the time calibration can be verified in a few seconds.

10. RELIABILITY AND EASE OF MAINTENANCE. Proved circuits are employed which have been in successful use for over a year and have given excellent service in production tests. Modular construction is used throughout, for easy troubleshooting and excellent accessibility of all components. Logical groups of modules are mounted in convenient slide-out chassis which permit access to every component while the equipment is in operation.

SPECIFICATIONS (Tentative) (obsoletes and supercedes all earlier specifications.) (October 1960)

SPECIFICATION	MODEL 400	MODEL 420
PARAMETERS MEASURED:	Functionswitches select any one of the following parameters: Risetime, turn-on delay, Turn-on time, Fall time, Storage time and Turn-off time. Upper test limits adjustable from 100% to 40%, lower limits from 0% to 60%.	Same
TIME RANGES: Voltage Output Meter	2 Ranges a) 0.5ns to 200ns b) 50ns to 1μsec† 9 Ranges 0 – 2, 5, 10ns 0— 10, 50, 100ns 0 – 200, 500, 1000ns†	2 Ranges a) 1.0ns to 200ns b) 100ns to 2μsec† 10 Ranges 0 – 2, 5, 10ns 0 – 20, 50, 100ns 0 – 200,500,1000ns† 0 – 2000ns†
ACCURACY*: Voltage Output Meter Reading	±4% of reading ±0.2ns As above, plus meter accuracy of ±2% (max) F.S.	±5% of reading ±0.4ns As above, plus meter accuracy of ±2% (max) F.S.
OUTPUTS:	(1) Reading on 4½ in mirror scale meter. –(2) 50mv/ns on range (a). (3) 5mv/ns on range (b) – (4) Go-No Go, digital, printed and punched information (optional)	Same
READOUT TIME (METER):	1 second max. (Faster readout times possible with reduced accuracy)	Same
NORMALIZING:	Accuracy of measurement is usually not affected by signal amplitude changes. Also usually not affected by overshoot or ringing in the leading edge of the waveform.	Same
SIGNAL RANGE: (Input to Test Set from Test Card)	200mv minimum can be as low as 25mv with internal adjustment (Proper output level is provided by test card for specified test conditions)	200mv minimum (Proper output level is provided by test card for specified test conditions.)
PROGRAMMING:	Manual, or automatic with Model 2120 Transistor Test Card. Automatically programs Base and Collector voltages and polarity; sets mercury pulser voltage and polarity; provides proper input and output signal levels. Base power supply and pulser output voltage and polarity can change automatically from "ON" to "OFF" tests.	Same
TEST SEQUENCE:	Selected by individual switches. Automatic Sequencing Optional.	Same
REMOTE TESTING:	Test fixture may be located remotely to permit automated production and environmental testing.	Same
PULSE GENERATOR: †	Built-in: 0.3ns Risetime, 120 cps nominal, 200ns pulse width. (Provision included for use of external pulse generators for time measurements exceeding 200ns).	Same
POWER SUPPLIES:	Collector and base (2) Highly regulated, programmable. Continuously variable to 36v, 200 ma. Other values optional.	Same
CONSTRUCTION:	Main unit mounted in console, 22" wide, 29" high. 4 slide-out drawers. Each drawer 19" wide, suitable for rack mounting. Total combined height of unmounted drawers – 26". Power supply in separate 11" high enclosed unit. (rack mounting optional).	Single unit, including power supply, mounted in console, 22" wide, 29" high. 4 slide-out drawers. Each drawer 19" wide, suitable for rack mounting. Total combined height of unmounted drawers – 26".

† External pulse generator required for measurements over 200ns to provide pulse widths over 200ns (optional).
*Accuracy specification applies to transistors switching into saturation or for linearly rising or falling waveforms. The max. error of the output signal is the arithmetic sum of *peak* errors possible within the system. Test conditions and measurements other than those specified may result in increased, or decreased accuracy. For example, accuracy will increase for delay measurements and may decrease for signals having non-linear, or exponential waveforms.

TEST CIRCUIT CARD SPECIFICATIONS	
Model 2120 TRANSISTOR TEST CARD, BASIC	Plug-in card (printed circuit on Epoxy Fiberglass board) permits proper and convenient construction of user's nanosecond test circuit, and mounting of programming resistors. Includes basic components common to all test circuits; fits matching connector in Test Fixture. Low capacity, high frequency construction for nanosecond work. Special, low capacity transistor socket adaptable for long and short leads. [redacted]
Model 2120W TRANSISTOR TEST CARD, WIRED	As above, but wired and tested to meet customer's specifications for circuit and test conditions. 1 card supplied with Model 400 and 420. (Customer must supply complete specifications and 10 ea. typical transistors to be tested).

ENGINEERING & ORDERING INFORMATION

The specifications in this brochure are tentative. LUMATRON carries on a continuing program of product improvement and strives to increase the capabilities of its instruments and to meet the changing requirements of a rapidly growing electronic industry. LUMATRON reserves the right to make changes in specifications and construction, and to modify design features without notice.

The Models 400 and 420 described in this brochure are standard instruments; however, modifications and options, as outlined above, are available. LUMATRON will be pleased to discuss any special requirements with you. For further information, please contact our nearest engineering field representative or write directly to the factory:

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